# Toothbrushing Behaviour and Periodontal Pocketing: An 11-year longitudinal study

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**Abstract**

**Aim:** To explore the association between toothbrushing behaviour and change in periodontal pocketing among adults.

**Methods:** We pooled data from 1025 adults, aged 30-89 years, who participated in two national surveys in Finland (Health 2000 and Health 2011, BRIF8901) and reported their toothbrushing frequency. A cumulative measure of regular toothbrushing was created by counting the number of times participants reported brushing twice or more daily across the two surveys (ranging from 0 to 2). The association between toothbrushing behaviour and the number of teeth with periodontal pocket depth (PPD)≥4mm over 11 years was assessed in linear regression models adjusting for confounders.

**Results:** There was a clear dose-response relationship between toothbrushing frequency (either at baseline or follow-up) and change in number of teeth with PPD≥4mm. There was also evidence of a cumulative effect of regular toothbrushing on change in number of teeth with PPD≥4mm. Participants who reported brushing twice or more a day in both surveys developed 1.99 (95% CI: 1.02 to 2.95) fewer teeth with PPD≥4mm than those who did not report this behaviour in any survey.

**Conclusion:** This 11-year prospective study showed that toothbrushing behaviour was associated with smaller increments in the number of teeth with periodontal pocketing.

**Clinical Relevance**

**Scientific rationale for study:** Evidence on the role of toothbrushing to prevent periodontal disease comes mainly from cross-sectional studies.

**Principal findings:** Regular toothbrushing, that is twice or more *every* day, can help prevent periodontal pocketing.

**Practical implications:** The present findings support current guidance and public health messages promoting toothbrushing behaviour.

## Introduction

Regular toothbrushing is the most common recommendation for personal oral hygiene (Public Health England/Department of Health, 2014, Tonetti et al., 2015, Jepsen et al., 2017). It is considered an important adjunct to professional mechanical plaque removal (Needleman et al., 2015). While there is evidence that toothbrushing, particularly when used in combination with fluoride toothpaste, prevents dental caries (Kumar et al., 2016, Wong et al., 2011); the same benefit has not been clearly demonstrated for periodontal diseases.

A recent systematic review reported a positive association between infrequent toothbrushing and periodontitis, with an odds ratio of 1.41 (95% Confidence Interval: 1.25-1.58). However, the pooled estimate was based on data from 12 cross-sectional studies and 2 case-control studies, with plenty of heterogeneity between studies (Zimmermann et al., 2015). Other limitations of the above review are the uncertainty about how frequent toothbrushing was defined (e.g. twice or more a day, once or more a day, and a positive response to a question on regular toothbrushing); the lack of adjustment for important confounders (i.e. socioeconomic position and daily smoking) in six studies; and the inclusion of two studies carried out in young adults among which periodontal disease is relatively rare (Worsley and Marshman, 2015). In addition, the review missed two early longitudinal studies with contradicting findings. On one hand, a 10-year longitudinal study among Danish youths followed from age 9-10 to 20-21 years found that participants brushing less than twice daily and those brushing twice daily had higher pocketing scores than those brushing more than twice daily (Lissau et al., 1990). On the other hand, a 7-year longitudinal study among older adults in North Carolina found no association between toothbrushing frequency and periodontal attachment loss (Elter et al., 1999).

Manual toothbrushing helps with plaque control and reduces gingivitis in the short- and long term (Yaacob et al., 2014, Tonetti et al., 2015). Whether that improvement will lead to lower incidence of periodontal disease is still unknown. The aim of this study was to explore the association between toothbrushing behaviour and changes in periodontal pocketing over 11 years among Finnish adults.

## Materials and Methods

### *Data source*

We used data from two national surveys in Finland (Health 2000 and Health 2011) conducted by the National Institute of Health and Welfare (THL, formerly the National Public Health Institute). The Health 2000 Survey (BRIF8901) was a national survey of the Finnish

population; the main sample including 8028 Finnish adults, aged 30 years and over, recruited using stratified two-stage cluster sampling. Of them, 6335 adults participated in clinical oral examinations (79%) and 5255 were dentate with complete data on periodontal status (Aromaa and Koskinen, 2004). The Health 2011 was a follow-up study of the Health 2000 Survey. All participants of the Health 2000 Survey, aged 18 years or over in 2000, alive and living in Finland were invited. The sample of those aged 30 years or over in 2011 consisted of 7964 adults, of whom 5806 (73%) participated in at least one part of the study and 4221 (53%) in the health examination. Only those adults living in Southern or Northern Finland (2 of the 5 examination areas, n=3713) were invited to participate in a new oral examination and 1496 agreed (40%) (Lundqvist and Mäki-Opas, 2016). The Ethical Committee for Research in Epidemiology and Public Health at the Hospital District of Helsinki and Uusimaa in Finland approved the Health 2000 and Health 2011 Surveys. A written informed consent was obtained from all participants.

Of the 1128 dentate adults at baseline who participated in the follow-up study, 1076 had periodontal data on both surveys. Fifty-one participants were excluded because of missing data on relevant covariates. Therefore, the study sample included 1025 dentate adults. The length of follow-up was approximately 11 years (mean: 130 months; range: 122-134 months). This manuscript adheres to the STROBE statement for human observational studies.

***Variables selection***

Participants reported their toothbrushing frequency, at both surveys, using five response options (more than twice a day, twice a day, once a day, less often than daily and never). Because there were few participants in each survey reporting never brushing, we merged these responses with those for brushing less often than daily. We also created a cumulative measure of regular toothbrushing by counting the number of times participants reported brushing twice or more often a day across the two surveys. The count ranged from 0 to 2; 0 for those who did not report brushing twice or more a day in any survey, 1 for those who reported brushing twice or more a day either at baseline or follow-up, and 2 for those who reported brushing twice or more a day in both surveys. Therefore, we used 3 indicators of toothbrushing behaviour: frequency at baseline, frequency at follow-up and regular toothbrushing.

Several risk factors for periodontal disease were included in the analysis as covariates. They were all measured at baseline. Demographic characteristics were sex and age. Socioeconomic position was indicated by participants' level of education grouped into three categories. Basic

education included no vocational training beyond a vocational course or on-the-job training with no matriculation examination. Secondary education included completion of vocational school and passing the matriculation examination but having no vocational training beyond a vocational course or on-the-job training. Higher education included degrees from higher vocational institutions, polytechnics and universities. Dental behaviours included daily smoking and dental attendance pattern. Smoking status was derived from answers to four questions: "have you ever smoked?", "have you ever smoked regularly (daily for at least one year), "have you smoked at least 100 times?" and "when did you last smoke?". Daily smokers were those who met all following conditions: smoked at least 100 times in their lifetime, regularly for at least 1 year, and most recently the day of the survey or the previous day (WHO, 1998). This definition has been used in previous analysis of the same data (Kanhai et al., 2014, Bernabe et al., 2014, Sabbah et al., 2015). Dental attendance pattern was reported on a 3-point response scale (regularly for check-ups, only when in trouble or never). Finally, diabetes was derived from the question "has a doctor ever diagnosed you with diabetes?".

Identical clinical oral examinations were conducted at baseline and follow-ups and were independent of participants' completion of questionnaires. Clinical examinations were performed by dentists, with participants seated on a dental chair and using a mouth mirror, fibre optic light, a World Health Organization periodontal probe and a headlamp. The periodontal status was determined by measuring periodontal pocket depth (PPD) on four sites per tooth (distal, mesial, mid-buccal and mid-lingual), excluding third molars and tooth remnants. All teeth with PPD$\geq$4mm at any site were recorded as having periodontal pockets. All the examiners (in 2000 and 2011) received similar training given by the same experienced dentists. In 2000, the percentage agreement in the parallel measurements on 269 survey participants, where field examiners were compared individually with the reference examiner under field conditions, was 77% (Kappa: 0.41) for periodontal pockets by tooth. Kappa values for intra-examiner reliability on 111 subjects were 0.83 (Suominen-Taipale et al., 2004, Suominen-Taipale et al., 2008). The outcome measure was the change in number of teeth with pocketing$\geq$4mm over 11 years, which was calculated by subtracting the number of teeth with pocketing at follow-up from the corresponding figure at baseline (for those teeth that were present and examined in both surveys) (Kanhai et al., 2014).

***Statistical analysis***

We first compared the characteristics of the study sample with those of participants excluded because of missing data, using the Chi-square test. The 11-year change in number of teeth with

PPD≥4mm was also compared according to participants' characteristics at baseline using the t-test when there were two groups (sex, diabetes, smoking and dental attendance pattern) and analysis of variance (ANOVA) when there were more than two groups (age and education). In addition, toothbrushing frequency at baseline and follow-up were compared by sociodemographic factors, diabetes and dental behaviours using the Chi-square test.

The association between each indicator of toothbrushing behaviour and 11-year change in number of teeth with PPD≥4mm was estimated in linear regression models. The three indicators, toothbrushing frequency at baseline, toothbrushing frequency at follow-up and regular toothbrushing (cumulative measure) were modelled separately. We reported both crude and adjusted associations for the three set of models. Adjusted models controlled for sociodemographic factors (sex, age and education), diabetes, dental behaviours (daily smoking and dental attendance pattern) and number of teeth. Linear trends for the association of each indicator of toothbrushing behaviour with change in number of teeth with PPD≥4mm were assessed by fitting the former as a continuous variable in linear regression models.

We then explored whether the association between each indicator of toothbrushing behaviour and 11-year change in number of teeth with PPD≥4mm varied according to baseline level of periodontal pocketing. We addressed this question in sensitivity analysis following advice not to adjust for baseline scores when modelling change in scores as this approach generates collinearity due to mathematical coupling (Tu et al., 2004, Tu et al., 2005, Glymour et al., 2005, Van Breukelen, 2006). To that end, we tested the significance of the statistical interaction between baseline number of teeth with PPD≥4mm and the corresponding toothbrushing indicator when added to the main effects model. To help interpretation, we reported adjusted change in number of teeth with PPD≥4mm at three points in the distribution of baseline number of teeth with PPD≥4mm (zero, the sample mean=4.2 and one SD above the mean=10).

**Results**

Data from 1025 dentate adults aged 30 years and over at baseline were analysed with mean age 46.6 years (Standard Deviation: 10.6; range: 30 to 75). Table 1 presents the baseline characteristics of the study sample. No differences were noted between the study sample and participants excluded because of missing values on covariates. At baseline, the mean number of natural teeth was 24.8 (SD: 6.5, range: 3 to 32) and the mean number of teeth with PPD≥4mm was 4.2 (SD: 5.7, range: 0 to 28). The mean 11-year change in number of teeth with PPD≥4mm was 1.0 (SD: 6.0; range: -23 to 24). The increment in number of teeth with

PPD≥4mm was significantly larger in men, younger adults, daily smokers and those who visited the dentist only when in trouble.

Overall, 71.0% and 74.7% of participants reported brushing twice or more a day at baseline and follow-up, respectively. Brushing twice or more a day was more commonly reported among women, more educated adults, non-smokers and those who visited the dentist regularly for check-ups, in both the baseline and follow-up surveys (Table 2). No differences in toothbrushing frequency were found among age groups or between participants with and without diabetes.

Inverse gradients were found for each indicator of toothbrushing frequency and change in number of teeth with PPD≥4mm over 11 years (Table 3). Participants brushing once, twice and more than twice daily at baseline had, respectively, 2.24 (95% Confidence Interval; 0.13 to 4.35), 3.76 (95% CI; 1.67 to 5.85) and 3.88 (95% CI: 1.51 to 6.26) fewer teeth developing PPD≥4mm over 11 years than those brushing less often than daily. The regression coefficients for those brushing once a day and those brushing twice a day were significantly different ($p<0.001$), but the coefficients for those brushing twice a day and more than twice a day were not statistically different ($p=0.847$). Similarly, participants who reported brushing once, twice and more than twice daily at baseline had, respectively, 3.64 (95% CI: 1.21 to 5.90), 4.81 (95% CI: 2.51 to 7.07), 4.54 (95% CI: 1.76 to 7.32) fewer teeth developing PPD≥4mm over 11 years than those brushing less often than daily. The regression coefficients for those brushing once a day and twice a day were significantly different ($p=0.012$), but not the coefficients for those brushing twice a day and more than twice a day ($p=0.751$).

There was also evidence of a cumulative effect of regular toothbrushing on the change in number of teeth with PPD≥4mm, even after adjustments for confounders. Participants who reported brushing twice or more a day in both surveys had 1.96 (95% CI: 0.98 to 2.93) fewer teeth developing PPD≥4mm over 11 years than those who did not report this level of brushing in any survey. No differences were found between participants who reported brushing twice or more a day in one survey (either 2000 or 2011) and those who reported this level of brushing in neither survey. Our sensitivity analysis showed that the protective effect of toothbrushing behaviour on the change in number of teeth with PPD≥4mm was stronger among adults with more pocketing at baseline (Table 4). On one hand, no differences were found in the change in number of teeth with PPD≥4mm by toothbrushing behaviour among adults with no teeth with PPD≥4mm at baseline. On the other hand, toothbrushing behaviour was inversely associated

with the change in number of teeth with PPD≥4mm among adults with an average of 4 and 10 teeth affected at baseline (mean and one SD above the mean, respectively).

**Discussion**

This longitudinal study showed that toothbrushing behaviour was inversely associated with periodontal pocketing among Finnish adults. An association with periodontal pocketing was found not only with toothbrushing frequency reported at baseline and follow-up, but also with a cumulative measure of regular toothbrushing (i.e. brushing twice or more a day across the two surveys). The findings were not explained away by various well-known determinants of periodontal disease.

Some study limitations must be addressed before interpreting the present findings. First, although the study sample was large and drawn from two national surveys, we used data from participants living in Northern and Southern Finland. Therefore, the present findings represent valid relationships between the variables of interest but cannot be generalized to the entire Finnish adult population. Second, periodontal status was assessed as pocket depth, which reflects current activity rather than accumulated past disease –as opposed to clinical attachment loss– (Holtfreter et al., 2015, Savage et al., 2009). Also, four periodontal sites were inspected per tooth, but only the worst code was recorded. Recording only the worst code per tooth underestimates the prevalence and severity of periodontal disease (Susin et al., 2005, Kingman et al., 2008). Moreover, in 2000 the inter-examiner agreement for periodontal pockets was moderate, suggesting a certain degree of measurement bias. This is not a unique characteristic of this survey, but rather a standard feature across epidemiological surveys, reflecting the difficulty to examine and precisely measure periodontal pockets under field circumstances. Third, information on toothbrushing behaviour was collected through self-reports. Although some might argue that dental plaque indices provide a stronger assessment of oral cleanliness, there is evidence of good correlation between self-reported toothbrushing frequency and oral hygiene indices (Gil et al., 2015, Harnacke et al., 2015). More importantly, current recommendations on plaque control and oral hygiene maintenance are based on habitual toothbrushing behaviour, not clinical levels of dental plaque.

There was a clear dose-response relationship between toothbrushing behaviour and changes in periodontal pocketing. The magnitude of the effect was such that adults brushing twice or more a day (either at baseline or follow-up) had lower increments in the number of teeth with periodontal pocketing (i.e. preventing shallow pockets in up to 4 teeth) than those who brushed

less often than once a day. Although brushing once a day was sufficient to see clinical benefits on periodontal status (an average of 2 teeth with pocketing prevented), every increasing level of toothbrushing was associated with lower increments in the number of teeth with periodontal pocketing. That is, brushing once a day was better than brushing less often than daily, but worse than brushing twice a day. However, there was no difference between those brushing twice and more than twice daily. This might be due to the small number of participants reporting that level of toothbrushing, and therefore, such optimal level of oral self-care should not be discouraged.

We also found evidence that regular toothbrushing was associated with lower increments of periodontal pocketing during the 11-year period. Participants who consistently (across the two surveys) brushed their teeth twice or more a day had, on average, 2 teeth with shallow pockets that were prevented. The fact that no benefit was found among those who reported brushing twice or more a day in one survey only (either 2000 or 2011) underscores the importance of regular (long-term) self-care. Our findings provide stronger evidence than a recent meta-analysis (Zimmermann et al., 2015), as we are the first to provide robust longitudinal evidence on the topic. They are also in agreement with findings from the Dunedin longitudinal study, where individuals in the high-dental-plaque-trajectory group during the first three decades of life were not only more likely to have periodontal disease, but also, experiencing it more severely, than those in the low- and medium-dental-plaque-trajectory groups (Broadbent et al., 2011).

Our sensitivity analysis showed consistent estimates for the effect of toothbrushing behaviour in models unadjusted and adjusted for baseline pocketing despite collinearity between baseline and change in pocketing –i.e. the former is used to derive the latter– (Tu et al., 2004, Glymour et al., 2005). We also found a stronger effect of toothbrushing behaviour among adults with more periodontal pocketing. This finding suggests the presence of regression to the mean; that is, the tendency of observations that are extreme by chance to move closer to the mean when repeated (Glymour et al., 2005, Van Breukelen, 2006). Therefore, this finding awaits corroboration from randomised controlled trials or observational studies with more than two waves of data collection where the multilevel model of change could be used to formally evaluate the correlation between baseline and change in periodontal pocketing.

The present findings support current guidance and public health messages promoting toothbrushing behaviour (Public Health England/Department of Health, 2014, Tonetti et al., 2015, Jepsen et al., 2017). Regular toothbrushing (twice or more daily *every* day) will help

tackling the two most common oral diseases worldwide (Kassebaum et al., 2017). It will help preventing dental caries through the use of the toothbrush as a vehicle for the topical administration of fluoride toothpaste (Kumar et al., 2016); and periodontal diseases by the mechanical removal of dental plaque (Zimmermann et al., 2015), because using a dentifrice provides no additional benefit in plaque removal (Valkenburg et al., 2016). The challenge ahead is to develop effective interventions to support the adoption and maintenance of favourable oral self-care habits. As for research, further longitudinal studies in alternative settings and age groups would help corroborate and generalize the present findings. Those studies would benefit from including multiple assessment of toothbrushing behaviour over time and full-mouth periodontal examinations.

In conclusion, this longitudinal study showed a clear dose-response association between toothbrushing behaviour and change in periodontal pocketing among Finnish adults. Regular toothbrushing, that is twice or more *every* day, can help prevent periodontal disease.

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**Table 1.** Description of the sample and mean change in number of teeth with PPD≥4mm, by baseline characteristics (n=1025)

| Baseline characteristics | n | % | Mean | (SD) |
|---|---|---|---|---|
| *Sex* | | | | |
| Men | 459 | 44.8 | 1.4 | (6.9) |
| Women | 566 | 55.2 | 0.7 | (5.1) |
| *P value*[a] | | | *0.042* | |
| *Age groups* | | | | |
| 30-34 years | 155 | 15.1 | 1.2 | (5.0) |
| 35-44 years | 323 | 31.5 | 1.9 | (6.2) |
| 45-54 years | 305 | 29.8 | 0.5 | (6.1) |
| 55-64 years | 187 | 18.2 | 0.6 | (5.7) |
| 65+ years | 55 | 5.4 | -0.8 | (6.2) |
| *P value*[a] | | | *0.003* | |
| *Education* | | | | |
| Basic | 206 | 20.1 | 0.9 | (5.2) |
| Secondary | 345 | 33.7 | 1.5 | (7.1) |
| Higher | 474 | 46.2 | 0.7 | (5.4) |
| *P value*[a] | | | *0.176* | |
| *Diabetes* | | | | |
| No | 1005 | 98.0 | 1.0 | (5.9) |
| Yes | 20 | 2.0 | -1.3 | (7.2) |
| *P value*[a] | | | *0.097* | |
| *Daily smoking* | | | | |
| No | 829 | 80.9 | 0.6 | (5.4) |
| Yes | 196 | 19.1 | 2.5 | (7.6) |
| *P value*[a] | | | *<0.001* | |
| *Dental attendance pattern* | | | | |
| Regularly for check-ups | 667 | 64.9 | 0.7 | (5.8) |
| Only when in trouble | 358 | 34.9 | 1.5 | (6.2) |
| *P value*[a] | | | *0.046* | |

[a] T-test was used when comparing two groups and analysis of variance (ANOVA) when comparing more than two groups

**Table 2.** Brushing twice a day or more often at baseline (2000) and follow-up (2011), by baseline characteristics (n=1025)

| Baseline characteristics | Baseline | | Follow-up | |
|---|---|---|---|---|
| | n | % | n | % |
| *Sex* | | | | |
| Men | 256 | 55.7 | 274 | 59.7 |
| Women | 472 | 83.4 | 492 | 87.0 |
| *P value*[a] | *<0.001* | | *<0.001* | |
| *Age groups* | | | | |
| 30-34 years | 111 | 71.6 | 122 | 78.7 |
| 35-44 years | 229 | 70.9 | 232 | 71.8 |
| 45-54 years | 223 | 73.1 | 237 | 77.7 |
| 55-64 years | 125 | 66.8 | 141 | 75.4 |
| 65+ years | 40 | 72.7 | 34 | 61.9 |
| *P value*[a] | *0.673* | | *<0.059* | |
| *Education* | | | | |
| Basic | 128 | 62.1 | 142 | 68.9 |
| Secondary | 228 | 66.1 | 233 | 67.6 |
| Higher | 372 | 78.5 | 391 | 82.5 |
| *P value*[a] | *<0.001* | | *<0.001* | |
| *Diabetes* | | | | |
| No | 713 | 71.0 | 748 | 74.5 |
| Yes | 15 | 75.0 | 18 | 90.0 |
| *P value*[a] | *0.692* | | *0.113* | |
| *Daily smoking* | | | | |
| No | 603 | 72.7 | 635 | 76.6 |
| Yes | 125 | 63.8 | 131 | 66.9 |
| *P value*[a] | *0.013* | | *0.005* | |
| *Dental attendance pattern* | | | | |
| Regularly for check-ups | 506 | 75.8 | 526 | 78.8 |
| Only when in trouble | 222 | 62.0 | 240 | 67.0 |
| *P value*[a] | *<0.001* | | *<0.001* | |

[a] Chi-square test was used for comparison.

**Table 3.** Association between different indicators of toothbrushing behaviour and 11-year change in number of teeth with PPD≥4mm (n=1025)

| Toothbrushing behaviour | 11-yr change | | Crude associations | | Adjusted associations[b] | |
|---|---|---|---|---|---|---|
| | Mean | (SD) | Coef.[a] | [95% CI] | Coef.[a] | [95% CI] |
| *Toothbrushing frequency in 2000* | | | | | | |
| Less than once a day (n=93) | 4.6 | (7.7) | 0.00 | [Reference] | 0.00 | [Reference] |
| Once a day (n=635) | 2.1 | (6.1) | -2.45 | [-4.55, -0.35]* | -2.24 | [-4.35, -0.13]* |
| Twice a day (n=263) | 0.5 | (5.6) | -4.11 | [-6.14, -2.00]*** | -3.76 | [-5.85, -1.67]*** |
| More than twice a day (n=34) | 0.0 | (6.6) | -4.59 | [-6.90, -2.28]*** | -3.88 | [-6.26, -1.51]** |
| *P value for trend* | | | | *<0.001* | | *<0.001* |
| *Toothbrushing frequency in 2011* | | | | | | |
| Less than once a day (n=54) | 5.3 | (7.3) | 0.00 | [Reference] | 0.00 | [Reference] |
| Once a day (n=712) | 2.0 | (6.3) | -3.30 | [-5.70, -0.96]*** | -3.64 | [-5.98, -1.29]** |
| Twice a day (n=232) | 0.5 | (5.8) | -4.80 | [-7.10, -2.53]*** | -4.81 | [-7.11, -2.51]*** |
| More than twice a day (n=27) | 0.4 | (4.6) | -4.92 | [-7.64, -2.20]*** | -4.54 | [-7.32, -1.76]** |
| *P value for trend* | | | | *<0.001* | | *<0.001* |
| *Brushed 2+/day in 2000 and 2011* | | | | | | |
| Never (n=209) | 2.5 | (6.3) | 0.00 | [Reference] | 0.00 | [Reference] |
| One period only (n=138) | 1.8 | (6.7) | -0.80 | [-2.07, 0.47] | -0.61 | [-1.88, 0.65] |
| Both periods (n=678) | 0.3 | (5.6) | -2.26 | [-3.17, -1.34]*** | -1.96 | [-2.93, -0.98]*** |
| *P value for trend* | | | | *<0.001* | | *<0.001* |

[a] Linear regression was fitted and regression coefficients (coef.) reported.

[b] Models were adjusted for sex, age groups, education, diabetes, daily smoking, dental attendance pattern and number of teeth.

* p<0.05, ** p<0.01, *** p<0.001

**Table 4.** Association between different indicators of toothbrushing behaviour and 11-year change in number of teeth with PPD≥4mm at different levels of baseline number of teeth with PPD≥4mm (n=1025)

| Toothbrushing indicator | Number of teeth with PPD≥4mm at baseline | Toothbrushing groups | Coef.[a] | [95% CI] |
|---|---|---|---|---|
| *Toothbrushing frequency in 2000* | None | Less than once a day | 0.00 | [Reference] |
| | None | Once a day | 0.87 | [-1.62, 3.36] |
| | None | Twice a day | 0.31 | [-2.15, 2.77] |
| | None | More than twice a day | 0.89 | [-1.83, 3.61] |
| | Mean (4.2 teeth) | Less than once a day | 0.00 | [Reference] |
| | Mean (4.2 teeth) | Once a day | -1.45 | [-3.41, 0.51] |
| | Mean (4.2 teeth) | Twice a day | -2.71 | [-4.65, -0.76]** |
| | Mean (4.2 teeth) | More than twice a day | -3.42 | [-5.61, -1.22]** |
| | +1SD (10 teeth) | Less than once a day | 0.00 | [Reference] |
| | +1SD (10 teeth) | Once a day | -4.65 | [-6.84, -2.46]*** |
| | +1SD (10 teeth) | Twice a day | -6.87 | [-8.99, -4.76]*** |
| | +1SD (10 teeth) | More than twice a day | -9.36 | [-11.99, -6.73]*** |
| *Toothbrushing frequency in 2011* | None | Less than once a day | 0.00 | [Reference] |
| | None | Once a day | -2.32 | [-5.20, 0.56] |
| | None | Twice a day | -2.31 | [-5.14, 0.52] |
| | None | More than twice a day | -1.99 | [-5.30, 1.31] |
| | Mean (4.2 teeth) | Less than once a day | 0.00 | [Reference] |
| | Mean (4.2 teeth) | Once a day | -3.24 | [-5.51, -0.97]** |
| | Mean (4.2 teeth) | Twice a day | -4.25 | [-6.48, -2.02]*** |
| | Mean (4.2 teeth) | More than twice a day | -4.52 | [-7.17, -1.87]** |
| | +1SD (10 teeth) | Less than once a day | 0.00 | [Reference] |
| | +1SD (10 teeth) | Once a day | -4.51 | [-6.83, -2.18]*** |
| | +1SD (10 teeth) | Twice a day | -6.94 | [-9.17, -4.72]*** |
| | +1SD (10 teeth) | More than twice a day | -8.01 | [-11.47, -4.54]*** |
| *Brushed 2+/day in 2000 and 2011* | None | Never | 0.00 | [Reference] |
| | None | One period only | 1.84 | [0.43, 3.24]* |
| | None | Both periods | 0.07 | [-0.99, 1.14] |
| | Mean (4.2 teeth) | Never | 0.00 | [Reference] |
| | Mean (4.2 teeth) | One period only | -0.53 | [-1.67, 0.60] |
| | Mean (4.2 teeth) | Both periods | -3.81 | [-5.37, -2.25]*** |
| | +1SD (10 teeth) | Never | 0.00 | [Reference] |
| | +1SD (10 teeth) | One period only | -1.69 | [-2.56, -0.82]*** |
| | +1SD (10 teeth) | Both periods | -4.12 | [-5.27, -2.98]*** |

[a] Predicted change in number of teeth with PPD≥4mm derived from linear regression models including sex, age groups, education, diabetes, daily smoking, dental attendance, number of teeth, number of teeth with PPD>4mm and the two-way interaction between the toothbrushing indicator and number of teeth with PPD>4mm as explanatory variables.
* $p<0.05$, ** $p<0.01$, *** $p<0.001$